Chapter 840 Illumination

840.01 General

Illumination is provided along highways, in parking lots, and at other facilities to enhance the visual perception of conditions or features that require additional motorist, cyclist, or pedestrian alertness during the hours of darkness.

The Washington State Department of Transportation (WSDOT) is responsible for illumination on state highways and crossroads (per WAC 468-18-050 and WAC 468-18-040) with partial limited access control, modified limited access control, or full limited access control, regardless of the location. WSDOT is responsible for illumination on state highways and crossroads (per WAC 468-18-050) with managed access control, located outside the corporate limits of cities. Cities are responsible for illumination of managed access state highways within their corporate limits.

For the definition of the types of access control—limited access control and managed access control—see Chapter 1425. For further information, see the "Access Control Tracking System, Limited Access and Managed Access Master Plan," under the 'related sites' heading at: http://www.wsdot.wa.gov/eesc/design/access/. This document provides a listing (by milepost) of the limited access or managed access status for all state highways. (See also the WSDOT/ Association of Washington Cities agreement "City Streets as Part of State Highways" at: http://www.wsdot.wa.gov/TA/Operations/LAG/CityStreets.html.)

840.02 References

Federal/State Laws and Codes

National Electrical Code, NFPA, Quincy, MA

Revised Code of Washington (RCW) 47.24.020, "Jurisdiction, control"

Washington Administrative Code (WAC) 296-24-960, "Working on or near exposed energized parts"

WAC 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

WAC 468-18-050, "Policy on the construction, improvement and maintenance of intersections of state highways and city streets"

Chapter 468-95 WAC, "Manual on uniform traffic control devices for streets and highways" (MUTCD)
http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

American National Standard Practice for Roadway Lighting, IES RP-8-00, New York, NY 2000

Directive D 22-21, "Truck Weigh Stations and Vehicle Inspection Facilities on State Highways"

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by WAC 468-95

NFPA 502: Standard for Road Tunnels, Bridges and Other Limited Access Highways, 2004, NFPA, Quincy, MA

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

Roadway Lighting Handbook, Federal Highway Administration, Implementation Package 78-15, Washington, DC 1978 (Reprinted April 1984)

Roadway Lighting Handbook, Addendum to Chapter Six: Designing the Lighting System Using Pavement Luminance, Federal Highway Administration, Addendum to Implementation Package 78-15, Washington, DC 1983

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01 WSDOT

Roadway Lighting Design Guide, AASHTO, October 2005

Supporting Information

An Informational Guide for Roadway Lighting, AASHTO, Washington, DC 1984

City Streets as a Part of State Highways, Final Report, WSDOT, 1997

Light Trespass: Research Results and Recommendations, IES TM-11-00, New York, NY 2000

Recommended Practice for Tunnel Lighting, IESNA RP-22-05, New York, NY 2005

840.03 Definitions

average light level The average of all light intensities within the design area.

complex ramp alignment and grade The exit advisory speed is 35 miles per hour or lower than the posted main line speed, or there is a 6% or greater change in grade from existing main line grade to the ramp grade.

continuous load When the electrical load on a circuit lasts for a duration of three hours or more on any day.

footcandle (fc) The illumination of a surface one square foot in area on which is uniformly distributed a flux of one lumen. One footcandle equals one lumen per square foot.

lamp lumens The total light output from a lamp, measured in lumens.

lumen The unit used to measure luminous flux.

luminaire A complete lighting unit comprised of a light bulb, wiring, and a housing unit.

luminance The quotient of the luminous flux at an element of the surface surrounding the point, and propagated in directions defined by an elementary cone containing the given direction, by the product of the solid angle of the cone and area of the orthogonal projection of the element of the surface on a plane perpendicular to the given direction. The luminous flux may be leaving, passing through, and/or arriving at the surface.

luminous flux The time rate of the flow of light.

maximum uniformity ratio The average light level within the design area divided by the minimum light level within the design area. (See Figure 840-25.)

maximum veiling luminance ratio This ratio is the maximum veiling luminance divided by the average luminance over a given design area for an observer traveling parallel to the roadway centerline. (See Figure 840-25.)

minimum light level The minimum light intensity of illumination at any single point within the design area measured just prior to relamping the system. (See Figure 840-25, Note 1.)

minimum average light level The average of all light intensities within the design area, measured just prior to relamping the system. (See Figure 840-25, Note 1.)

mounting height – luminaire The vertical distance between the surface of the design area and the center of the light source of the luminaire. Note: This is not to be confused with pole height (H1), but is the actual distance that the luminaire is located above the roadway edge line.

multimodal connection The point where multiple types of transportation activities occur; for example, where transit buses and van pools drop off or pick up passengers (including passengers with bicycles).

nighttime The period of time from one-half hour after sunset to one-half hour before sunrise and any other time when persons or objects may not be clearly discernable at a distance of 500 feet. (See RCW 46.04.200, Hours of Darkness.)

pedestrian crossing For the purpose of lighting design, the number of pedestrian movements that cross through the design area.

pole height (H1) The vertical distance from the light source to the pole base. This distance is specified in contracts and used by the pole manufacturers to fabricate the light standard.

roadway luminance The light projected from a luminaire that travels toward a given area, represented by a point on the pavement surface, and then back toward the observer, opposite to the direction of travel. The units of roadway luminance are footcandles.

security lighting A minimal amount of lighting used to illuminate areas for public safety or theft reduction. Security lighting for walkways is the lighting of areas where shadows and horizontal and vertical geometry obstruct a pedestrian's view.

slip base A mechanical base designed to allow the luminaire pole to break away from the fixed foundation when hit by a vehicle traveling at the design speed.

spacing The distance in feet measured on centerline between adjacent luminaires.

transit flyer stop A multimodal connection located within the boundaries of a limited access facility.

transit stop A connection on the highway where the transit bus stops to pick up or drop off passengers.

uniformity ratio The ratio of the minimum average light level on the design area to the minimum light level of the same area. (See Figure 840-25.)

veiling luminance The stray light produced within the eye by light sources produces a veiling luminance that is superimposed on the retinal image of the objects being observed. This stray light alters the apparent brightness of an object within the visual field and the background against which it is viewed, thereby impairing the ability of the driver to perform visual tasks. Conceptually, veiling luminance is the light that travels directly from the luminaire to the observer's eye.

840.04 Design Considerations

An illumination system is built from many separate components. The simplest illumination system contains:

- A power feed from the local utility company.
- An electrical service cabinet containing a photocell and circuit breaker for each illumination circuit.
- Runs of conduit with associated junction boxes leading to each luminaire.
- Conductors routed from the service cabinet breaker to each luminaire.
- A concrete light standard foundation.
- A luminaire pole with a slip base or a fixed base.
- A luminaire (light) over or near the roadway edge line.

There are design considerations that need to be addressed when performing even the most minimal work on an existing illumination system. An existing electrical system was acceptable for use under the design requirements and National Electric Code (NEC) rules in effect at the time of installation. When modifying an existing electrical system, the designer is responsible for bringing the whole system up to current NEC design standards. Retrofitting an existing fixed base luminaire pole with a slip base feature requires the installation of quick disconnect fittings and fuses in the circuit, at the luminaire. The existing conductor configuration for a fixed base luminaire is not acceptable for use on a breakaway (slip base) installation. Existing conductors and components that no longer meet current NEC requirements are to be replaced and the whole circuit designed to current standards. This may mean replacing the whole circuit back to the nearest overcurrent protection device (circuit breaker). The following are design considerations to be addressed when modifying an existing illumination system:

- Whether the existing circuit is in compliance with current NEC standards (deficient electrical component)
- Whether existing luminaire system components, such as conductors, conduit, junction boxes, foundation, and pole comply with current standards

- Whether conductors meet NEC requirements for temperature rating (deficient electrical component)
- Conductor material: aluminum conductors or copper conductors (deficient electrical component)
- The condition and adequacy of the existing conduit running between the luminaire and the nearest junction box (deficient electrical component)
- The condition of the junction box next to the luminaire (deficient electrical component)
- The suitability of the existing foundation to meet current design requirements
- The suitability of the location to meet current design standards for illumination
- The location and bolt pattern of existing foundation to meet current design standards
- The design life remaining for the existing luminaire pole (deficient electrical component)
- The condition of the existing luminaire pole (deficient electrical component)
- Maintenance personnel assessment of the electrical safety of the installation

Involve appropriate Headquarters (HQ) and region Traffic Office design personnel early in the scoping process. Ensure that potential system deficiencies are reflected in the estimate of work.

Another consideration is the need to maintain illumination during construction. Site preparation, widening, drainage, guardrail installation, or other work can easily impact existing conduit runs or luminaire locations. Furthermore, changed conditions such as merging, weaving, or unusual alignment due to traffic control often require additional temporary illumination. The same lighting requirements apply whether a condition is temporary or permanent.

840.05 Required Illumination

The design matrices identify the design levels for illumination on all preservation and improvement projects. (See Chapter 325.)

At the basic design level for minor safety or preservation work, providing slip base features on existing light standards (when in the Design Clear Zone or recovery area), and bringing electrical components to current standards, is required. Consider other minor safety work as necessary. Providing additional lighting or relocating light standards on preservation projects may be considered spot safety enhancements. When the Illumination column has an EU (evaluate upgrade to full design level), consider providing illumination if it would be beneficial to the specific project, and document accordingly.

- ***Evaluate Upgrade:*** Review the service to see that it meets current standards for design load. It should be located so that it can be safely accessed from the right of way. Poles, foundations, heads, etc., that have reached their design life should be replaced. Slip base features should be per current design standards. Uniformity should be evaluated in the design areas (see 840.07(2)). Locations that are illuminated per 840.05 should be brought to full standards or documented regarding why they are not (deferred to another project, etc.). Consider additional illumination per 840.06 if warranted, or design additional illumination if it is called for in the Project Definition.

  When it is necessary to relocate existing illumination pole foundations, evaluate the entire conduit run serving those poles and replace deficient components to current (NEC) standards.
- ***Full Standards:*** For full design level, the illumination specified in this chapter is required when constructing a new system and/or bringing the entire existing system to full standards (such as slip base features, grounding, conduit, light levels, and uniformity). On existing systems, this includes all components not otherwise affected by the project. Review all conduit runs, not just the one affected by relocating poles on that run.

Figures 840-1 through 840-24 show examples of illumination for roadway, transit flyer stops, parking lots, truck weigh stations, tunnels, bridges, work zones, and detour applications. Illumination is required in these examples and in the locations listed below.

For Minor Operational Enhancement projects using the design matrices in Chapter 340, illumination is not required.

(1) Freeway Off-Ramps and On-Ramps

Provide the necessary illumination for the design area of all freeway off-ramp gore areas and on-ramp acceleration tapers. (See 840.07(2) and Figures 840-1a, 1b, and 1c.)

(2) Freeway Ramp Terminals

Provide the necessary illumination for the design area. (See Figure 840-2.) Additional illumination is required if the intersection has left-turn channelization or a traffic signal.

(3) Intersections With Left-Turn Lane Channelization

Illumination of the intersection area and the left-turn storage area is required for intersections with painted or other low-profile pavement markings such as raised pavement markings. When the channelization is delineated with curbs, raised medians, or islands, illuminate the raised channelization from the beginning of the left-turn approach taper. Illumination of the secondary road intersecting the state highway can be beneficial to the motoring public. Funding and design, however, are the local agency's responsibility. Contact that agency to see whether they are interested in participating. (See Figures 840-3a and 3b.)

(4) Intersections With Traffic Signals

Illuminate all intersections with traffic signals on state highways. (See Figure 840-4.) Illumination of the crossroad is beneficial and the participation of the local agency is desirable. In cities with a population under 22,500, the state may assume responsibility for illumination installed on signal standards.

(5) Railroad Crossings With Gates or Signals

Railroad crossings with automated gates or signals on state highways are illuminated if there is nighttime train traffic. Within the corporate limits of a city, and outside limited access control, illumination is the responsibility of the city. Install luminaires beyond the railroad crossing, on the side of the roadway opposite the approaching traffic, so that illumination is behind the train. (See Figure 840-5.)

(6) Transit Flyer Stops

Illuminate the pedestrian-loading areas of transit flyer stops located within the limited access boundaries. (See Figure 840-6.)

(7) Major Parking Lots

All parking lots with usage exceeding 50 vehicles during the nighttime peak hour are considered major parking lots. Provide an illumination design that will produce the light levels shown in Figure 840-25. (See Figure 840-7 for the parking area and bus loading zone.) During periods of low usage at night, security lighting of only the parking area and bus loading zone is required. Provide an electrical circuitry design that allows the illumination system to be reduced to approximately 25% of the required light level.

(8) Minor Parking Lots

Minor parking lots have a nighttime peak hour usage of 50 or fewer vehicles. Provide security-level lighting for those lots owned and maintained by the state. Security lighting for a minor parking lot consists of lighting the entrance and exit to the lot. (See Figure 840-8.)

(9) Truck Weigh Sites

Provide illumination of the roadway diverge and merge sections, scale platforms, parking areas, and inspection areas of weigh sites. (See Figure 840-9.)

(10) Midblock Pedestrian Crossings

Illuminate the entire midblock pedestrian crossing, including the crosswalks, the refuge area in the roadway, and the sidewalks or shoulders adjacent to the crosswalk. When a raised median pedestrian refuge design is used, illuminate this raised channelization. (See Figure 840-10.)

(11) Tunnels

Long tunnels have a portal-to-portal length greater than the stopping sight distance. Provide both nighttime and daytime illumination for long tunnels. Consider illumination for short tunnels if the horizontal to vertical ratio is > 10:1. (See Chapter 650 and Figure 840-11.)

(12) Lane Reduction

Provide the necessary number of light standards to illuminate the design area of all highway lane reduction areas within the urban boundary. (See Figure 840-12.) This requirement does not apply to:

- The end of slow-moving vehicle turnouts.
- The end of the area where driving on shoulders is allowed.

(13) Intersections With Right-Turn Channelization

Illumination of the intersection area and the right-turn storage area is required for intersections with painted or other low-profile pavement markings such as raised pavement markings. Raised channelization such as curb, raised medians, and islands are to be illuminated from the beginning of the right-turn taper. For concurrent left-turn and right-turn channelization, where the left-turn lane and the left-turn taper are longer than the right-turn lane and taper, illuminate the roadway as described in 840.05(3), and include the right-turn lane area in the design area. (See Figure 840-13.) Illumination of the secondary road intersecting the state highway can be beneficial to the motoring public. Funding and design, however, are the local agency's responsibility. Contact that agency to see whether they are interested in participating.

(14) Same Direction Traffic Split Around an Obstruction

Provide the necessary number of light standards to illuminate the design area where traffic is split around an obstruction. This requirement applies to permanent and temporary same-direction split channelization. For temporary work zones, the obstruction is to be illuminated for the duration of the traffic split. (See Figure 840-14.)

(15) Add Lane Channelization

Provide the necessary number of light standards to illuminate the design area of freeway add lanes on high-volume roadways within the urban boundary. (See Figure 840-15.) This requirement does not apply to the following:

- The beginning of an add lane on a low-volume roadway in a rural area beyond the urban boundary
- The beginning of a slow-moving vehicle turnout
- The beginning of an area where driving on shoulders is allowed

(16) Roundabouts

Provide the necessary number of light standards to illuminate the design area of roundabouts. (See Chapter 915, "Roundabouts," and Figure 840-16.)

(17) Bridge Inspection Lighting

Provide the necessary number of light fixtures to illuminate the interior inspection areas of floating bridges and steel box girder bridges. (See Figure 840-17.)

(18) Freeway On-Ramps With Ramp Meter Signals

Provide the necessary number of light standards to illuminate freeway on-ramps with ramp meters, from the beginning of the on-ramp to the ramp meter stop bar. When there is an HOV bypass lane or a two-lane merge beyond the ramp meter, then provide illumination for the entire ramp from the beginning of the on-ramp to the ramp merge point with the main line. (See Figure 840-18.)

(19) Freeway-to-Freeway Ramp Connections

Provide the necessary number of light standards to illuminate freeway-to-freeway ramps that connect full limited access freeway systems from the exit ramp gore area to the main line merge area. (See Figure 840-19.)

(20) HOT (High Occupancy Toll) Lane Enter/Exit Zones

Provide the necessary number of luminaires to illuminate the design area of the enter/exit zones of the HOT Lane. (See Figure 840-20.)

(21) Chain-Up Parking Areas

Provide the necessary number of luminaires to illuminate the design area of the chain-up parking area. (See Figure 840-21.)

(22) Rest Areas

Provide illumination at the roadway diverge and merge sections within rest areas, the walkways between parking areas and rest room buildings, and the parking areas as for a major parking lot. (See Figure 840-22.)

(23) Overhead Sign Illumination

Provide sign lighting on overhead signs as discussed in Chapter 820. (See ***Design Manual*** Supplement, Overhead Sign Illumination [Lighting], August 5, 2005.)

840.06 Additional Illumination

At certain locations, additional illumination is desirable to provide better definition of nighttime driving conditions or to provide consistency with local agency goals and enhancement projects. For improvement projects on state highways, additional illumination is considered under certain circumstances, which are listed in this section. Justify the additional illumination in the Design Documentation Package (DDP).

Some conditions used in making the decision to provide additional illumination are:

- **Diminished Level of Service.** A mobility condition where the nighttime peak hour level of service is D or lower. To determine the level of service, use traffic volume counts taken during the evening peak hour. Peaking characteristics in urban areas are related to the time of day. Traffic counts taken in the summer between 4:30 P.M. and 7:30 A.M. may be used as nighttime volumes if adjustment factors for differences in seasonal traffic volumes are applied for November, December, and January.
- **Nighttime Collision Frequency.** When the number of nighttime collisions equals or exceeds the number of daytime collisions. An engineering study indicating that illumination will result in a reduction in nighttime collisions is required as justification. Consider the seasonal variations in lighting conditions when reviewing reported collisions. Collision reporting forms, using a specific time period to distinguish between "day" and "night," might not indicate the actual lighting conditions at the time of a collision. Consider the time of year when determining whether a collision occurred at nighttime. A collision occurring at 5:00 P.M. in July would be a daytime collision, but a collision occurring at the same time in December would be during the hours of darkness.
- The mitigation of nighttime pedestrian accident locations (PAL) requires different lighting strategies than vehicular accident locations. Provide light levels to emphasize crosswalks and adjacent sidewalks. Multilane highways with two-way left-turn lanes, in areas transitioning from rural land use to urban land use, or areas experiencing commercial growth or commercial redevelopment, are typically high-speed facilities with numerous road approaches and driveways. These approaches allow numerous vehicle entry and exit points and provide few crossing opportunities for pedestrians. Consider additional illumination for this condition.

(1) Highways

Proposals to provide full (continuous) illumination require the approval of the State Traffic Engineer. Regions may choose to develop system plans (regional or corridor-specific) for providing full (continuous) illumination. The approval of a system plan will eliminate the need for a project-specific approval from the State Traffic Engineer.

The decision whether to provide full (continuous) illumination is to be made in the scoping stage and communicated to the designers as soon as possible.

(a) On the main line of full limited access highways, consider full (continuous) illumination if a diminished level of service exists and any two of the following conditions are satisfied:

- There are three or more successive interchanges with an average spacing of 1 1/2 miles or less, measured from the center of each interchange or a common point such as a major crossroad.
- The segment is in an urban area.
- A nighttime collision frequency condition exists.
- A benefit/cost analysis between the required and full (continuous) illumination indicates a value added condition with the addition of continuous illumination.

(b) On the main line of highways without full limited access control, consider full (continuous) illumination if the segment of highway is in a commercial area and either a diminished level of service exists or a nighttime collision frequency exists, and an engineering study indicates that nighttime driving conditions will be improved.

(2) Ramps

At ramps, consider additional illumination when a diminished level of service exists for the ramps and any of the following conditions are present:

- The ramp alignment and grade are complex
- There are routine queues of five or more vehicles per lane at the ramp terminal during the nighttime peak hour due to traffic control features
- A nighttime collision frequency condition exists
- The criteria for continuous main line illumination have been satisfied

(3) Highway-to-Highway Ramp Connections

Provide the necessary number of light standards to illuminate highway-to-highway ramps that connect partial or modified limited access freeway systems or managed access highway systems, from the exit ramp gore area to the main line merge area. For an example of the ramp connection, see Figure 840-19.

(4) Crossroads

At crossroads, consider additional illumination when a diminished level of service exists and a nighttime collision frequency exists. Also, consider additional illumination if the crossroad is in a tunnel, an underpass, or a lid.

(5) Intersections Without Channelization

Consider illumination of intersections without channelization if a nighttime collision frequency requirement is satisfied or the intersection meets warrants for left-turn channelization. (See Figure 840-23.)

(6) Short Tunnels, Underpasses, or Lids

Consider illumination of short tunnels, underpasses, or lids if portal conditions result in brightness that is less than the measured daytime brightness of the approach roadway divided by 15 and the length to vertical clearance ratio is 10:1 or greater.

(7) Work Zones and Detours

Consider temporary illumination of the highway through work zones and detours when changes to the highway alignment or grade remain in place during nighttime hours, and when the following conditions may be present:

- When nonstandard roadway features such as narrow lanes, shoulders, or shy distance to barriers or structures are present

- When the temporary alignment includes abrupt changes in highway direction or lane shifts with substandard lane shift tapers
- When other unusual highway features such as abrupt lane edge drop-offs, sudden changes in pavement conditions, or temporary excavation or trenching covers are present
- When there is an anticipation of heavy construction truck traffic, possibly requiring flaggers, entering and exiting the highway during nighttime hours

For further information, see Chapter 810.

(8) Transit Stops

The responsibility for lighting at transit stops is shared with the transit agency. Consider illumination of transit stops with shelters, as they are usually indicative of higher passenger usage. Negotiation with the transit agencies is required for the funding and maintenance of this illumination. Negotiating a memorandum of understanding (MOU) with each transit agency is preferred over spot negotiations. If the transit agency is unable or unwilling to participate in the funding and maintenance of the illumination, a single light standard positioned to illuminate both the transit pullout area and the loading area can be considered.

(9) Bridges

Justification for illuminating the roadway and sidewalk portion of bridges is the same as that for highways on either end of the bridge with or without full limited access control, as applicable. Justification for illuminating the architectural features of a bridge structure requires the approval of the State Traffic Engineer. For justification for illuminating pedestrian walkways or bicycle trails under a bridge, see 840.06(11).

(10) Railroad Crossing Without Gates or Signals

Consider illumination of these facilities when:

- The collision history indicates that motorists experience difficulty in seeing trains or control devices.
- There are a substantial number of rail operations conducted during nighttime hours.
- The crossing is blocked for long periods due to low train speeds.
- The crossing is blocked for long periods during the nighttime.

For further information, see the MUTCD.

(11) Walkways and Bicycle Trails

Consider illumination of a pedestrian walkway if the walkway is a connection between two highway facilities. This might be between parking areas and rest room buildings at rest areas, between drop-off or pick-up points and bus loading areas at flyer stops, or between parking areas and bus loading areas or ferry loading zones (for example). Consider illuminating existing walkways and bicycle trails if security problems have been reported. Also, consider illumination if security problems are anticipated. Under these conditions, the walkways and bicycle trails are illuminated to the level shown in Figure 840-25.

840.07 Design Criteria

(1) Light Levels

Light levels vary with the functional classification of the highway, the development of the adjacent area, and the level of nighttime activity. Light level requirements for highways and other facilities are shown in Figure 840-25. These levels are the minimum average light levels required for a design area at the end of rated lamp life for applications requiring a spacing calculation. Light level requirements *are not applicable* for single light standards or security lighting installations where:

- The light level is reduced to approximately 25% of the required light level in parking lots and parking lot loading areas during periods of low usage at night.
- Walkway or path illumination is installed only at areas where shadows and horizontal and vertical geometry obstruct a pedestrian's view.

Light level requirements *are applicable* for:

- Walkway or path illumination where, for public safety, the complete walkway or path is to be illuminated.

For design-level classifications of highways, see Chapters 325, 410, 430, and 440.

(a) **Activity Areas.** The types of activity areas (shown below) are related to the number of pedestrian crossings through the design area. These crossings need not occur within a single crosswalk and can be at several locations along the roadway in an area with pedestrian generators. Land use and activity classifications are as follows:

- **High Activity.** Areas with over 100 pedestrian crossings during the nighttime peak hour pedestrian usage. Examples include downtown retail areas; near outdoor stage theaters, concert halls, stadiums, and transit terminals; and parking areas adjacent to these facilities.
- **Medium Activity.** Areas with pedestrian crossings that number between 11 and 100 during the nighttime peak hour pedestrian usage. Examples include downtown office areas; blocks with libraries, movie theaters, apartments, neighborhood shopping, industrial buildings, and older city areas; and streets with transit lines.
- **Low Activity.** Areas with pedestrian crossings that number less than 11 during the nighttime peak hour pedestrian usage. Examples include suburban single-family areas, low-density residential developments, and rural or semirural areas.

(2) Design Areas

The design area is that portion of the roadway, parking lot, or other facility subject to the minimum light level, minimum average light level, uniformity ratio, and maximum veiling luminance ratio design requirements. This encompasses the area between the edges of the traveled way along the roadway; the outer edges of the stopping points at intersections; and, when present, a bike lane adjacent to the traveled way. When the roadway has adjacent sidewalks, the design area includes these features, except that sidewalks adjacent to the traveled way are exempt from maximum veiling luminance ratio requirements. The access areas used for interior inspection of a floating bridge or steel box girder bridge are exempt from lighting level and lighting ratio design requirements.

Design area requirements for various applications are shown in Figures 840-1 through 840-24 and the following:

- **Single-Lane Off-Ramp.** Two main line through lanes and the ramp lane, including gore area, from the gore point to a point 200 feet (minimum) downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.
- **Two-Lane Off-Ramp.** Two main line through lanes and both ramp lanes, including gore area, from a point 200 feet upstream of the gore point to a point 200 feet downstream from the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.
- **Single-Lane On-Ramp.** Two main line through lanes and the ramp lane, from a point where the ramp lane is 10 feet wide to a point 200 feet downstream. A 100-foot longitudinal tolerance either way is allowed (this includes auxiliary lane on-connections and lane reductions).
- **Two-Lane On-Ramp.** Two main line through lanes and the ramp lanes from a point where the ramp width is 22 feet wide to a point 200 feet upstream and 200 feet downstream. A 100-foot longitudinal tolerance either way is allowed.
- **Intersections Channelized With Pavement Markings.** The design area has two components: the intersection area and the approach areas. The intersection area is the area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks. The approach areas are the areas on the main roadway between the stopping point and where the left-turn lane is full width.
- **Intersections With Raised Channelization.** The design area has two components: the intersection area and the approach areas. The intersection area is the area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks. The approach areas are the areas on the main roadway between the stopping point and where the left-turn taper begins.

- **Unchannelized Intersection.** The area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks.
- **Railroad Crossings.** The roadway width from a point 50 feet on either side of the track (the approach side only for one-way roadways).
- **Transit Loading Areas.** The lane width and length designated for loading.
- **Major Parking Lots.** The entire area designated for parking, including internal access lanes.
- **Scale Platforms at Weigh Sites.** The approach width from the beginning of the scale platform to the end of the platform.
- **Inspection Areas at Weigh Sites.** The area dedicated to inspection as agreed upon with the Washington State Patrol.
- **Bridge Inspection Lighting System.** Fixtures are to be ceiling-mounted with a maximum spacing of 25 feet. Illumination is to consists of a 100 watt incandescent (or fluorescent equivalent) fixture. Each fixture is to be designed with a 20 amp rated ground fault circuit interrupt (GFCI) receptacle. A light switch is needed at each entrance to any common inspection area. For inspection areas with two or more entrances, three-way or four-way switches are required.

(3) Light Levels for Tunnels and Underpasses (Daytime Illumination)

It is important to provide sufficient lighting when illuminating the inside of a tunnel. When driving into and through a tunnel, a driver's eyes have to adjust from a high light level (daylight) to a lower lighting level inside the tunnel. Motorists require sufficient time for the eye to adapt to the lower light level of the tunnel itself. When sufficient lighting is not provided in the threshold, transition, or interior zones of a tunnel, a motorist's eyes may not have enough time to adapt to the lower light levels in the tunnel and the motorist experiences a "black hole" or "blackout" effect. This "black hole" effect may cause a motorist to slow down, reducing the efficiency of the roadway. As the motorist leaves the tunnel, the driver's eyes have to adjust from a low lighting level back to daytime conditions. The full design considerations for tunnel lighting are covered in 840.02, References, in the Supporting Information section. All designs for lighting tunnels are to be reviewed and approved by the State Traffic Engineer.

- Long tunnels are divided into zones for the determination of daytime light levels. Each zone is equal in length to the pavement stopping sight distance. The entrance zone beginning point is a point outside the portal where the motorist's view is confined to the predominance of the darkened tunnel structure.
- The daytime entrance zone light level is dependent upon the brightness of the features within the motorists' view on the portal approach. The brightness level is defined as the average brightness measured over a 20° cone at a point 500 feet in advance of the portal. The entrance zone light level produced within the tunnel must be sufficient to provide a brightness level of approximately 5% of the measured portal brightness, after adjustment for the reflectivity of the roadway, walls, and ceiling. Design successive zones for a daytime light level of 5% of the previous zone light level to a minimum value of five footcandles. Requirements for nighttime light levels for long tunnels on continuously illuminated roadways are the same as the light level required on a roadway outside the tunnel. Provide illumination of fire protection equipment, alarm pull boxes, phones, and emergency exits in long tunnels. (See NFPA 502 for additional information.)
- A short tunnel or underpass has a length-to-vertical clearance ratio of 10:1 or less. Short tunnels and underpasses in rural areas or with low pedestrian usage normally do not have daytime illumination. Short tunnels and underpasses in urban areas with high pedestrian usage may require daytime and nighttime illumination. Consultation with the affected local agency is recommended. Short tunnels and underpasses with length-to-vertical clearance ratios greater than 10:1 are treated the same as an entrance zone on a

long tunnel to establish daytime light levels. Short tunnels and underpasses where the exit portal is not visible from the entrance portal due to curvature of the roadway are to be considered long tunnels. Nighttime light level requirements for short tunnels on continuously illuminated roadways are the same as the light level required on the roadway outside the tunnel.

(4) Light Standards

(a) **Light Standards**. Light standards are the most common supports used to provide illumination for highway facilities. The 40-foot and 50-foot-high light standards with slip bases and Type 1 mast arms are used predominately on state highways. The angular Type 2 mast arms are allowed only to match existing systems. Use Type 1 mast arms on all new systems. Cities and counties may elect to use different mounting heights to address factors unique to their environments. On state highways, alternate light standards may be considered if requested by the city or county, provided they agree to pay any additional costs associated with this change.

The typical location for a light standard is on the right shoulder. When considering designs for light standards mounted on concrete barrier in the median, consider the total life cycle cost of the system, including the user costs resulting from lane closures required for relamping and repair operations. Light standards located in the vicinity of overhead power lines require a minimum 10-foot circumferential clearance from the power line (including the neutral conductor) to any portion of the light standard or luminaire. Depending on the line voltage a distance greater than 10 feet may be required (see WAC 296-24-960). Consult the Headquarters (HQ) Bridge and Structures Office when mounting light standards on structures such as retaining walls and bridge railings.

It is preferable to locate a light standard as far from the traveled way as possible to reduce the potential of impacts from errant vehicles. The preferred position for the luminaire is directly over the edge line. However, some flexibility is acceptable with the luminaire position to allow for placement of the light standard. On Type III signal standards, luminaires may be placed more than 4 feet from the edge line. Standard mast arm lengths are available in 2-foot increments between 6 and 16 feet. The preferred design for a single-arm light standard is a 16-foot mast arm installed on a 40-foot or 50-foot standard. The maximum allowable mast arm length for a single-arm light standard is 16 feet. The preferred design for a double mast arm light standard has mast arms between 6 feet and 12 feet in length, installed on a 40-foot or 50-foot standard. The maximum allowable mast arm length for a double luminaire light standard is 12 feet.

When light standards are located within the Design Clear Zone, breakaway and slip base features are used to reduce the severity of an impact. (See Chapter 700 for additional guidance on clear zone issues.)

In curb and sidewalk sections, locate the light standard behind the sidewalk. Slip bases on light standards are a safety requirement for roadways where the posted speed is 35 miles per hour or higher. They are not always desirable at other locations. Following are locations where fixed bases are installed:

- Parking lots
- Medians where the light standard is mounted on median barrier
- Behind traffic barrier, beyond the barrier's deflection design value (see Chapter 710)
- Along pedestrian walkways, bike paths, and shared-use paths

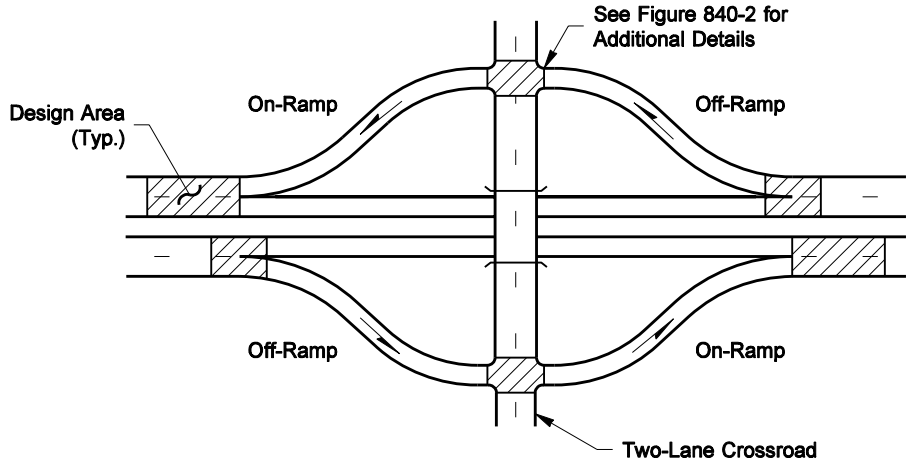
(b) **Light Standard Heights.** Standard pole heights (20-foot, 30-foot, 40-foot, or 50-foot) are readily available from local distributors and manufacturers. Light standards can also be supplied with other lengths. However, WSDOT maintenance offices cannot stock poles with nonstandard lengths for use as replacements in the event of a knockdown. Nonstandard lengths in 5-foot increments (25-foot, 35-foot, or 45-foot) will require a longer delivery time. Other nonstandard lengths (for example 27-foot, 33-foot, 43-foot, or 47-foot) will not only require a longer delivery time, they will also be more expensive.

In almost all cases, use standard pole heights of 40 feet and 50 feet for roadway illumination. Structure-mounted light standards may need to be shorter than the standard 40-foot or 50-foot grade-mounted pole. Use of 20-foot or 30-foot light standards on bridges, retaining walls, or other structures to compensate for top-of-structure elevation above the roadway surface is acceptable. Use of these standard pole heights will result in variable mounting heights for the luminaires. Luminaire mounting height is defined as the actual distance from the roadway surface directly under the luminaire to the luminaire itself. Use the actual mounting height at each location when calculating light standard spacing. High mast light supports may be considered for complex interchanges where continuous lighting is justified. High mast lighting may be considered for temporary illumination areas during construction. Initial construction costs, long-term maintenance, clear zone mitigation, spillover light onto adjacent properties, and negative visual impacts are important factors when considering high mast illumination. Shorter light standards of 30 feet or less may be used for minor parking lots, trails, pedestrian walkways, and locations with restricted vertical clearance.

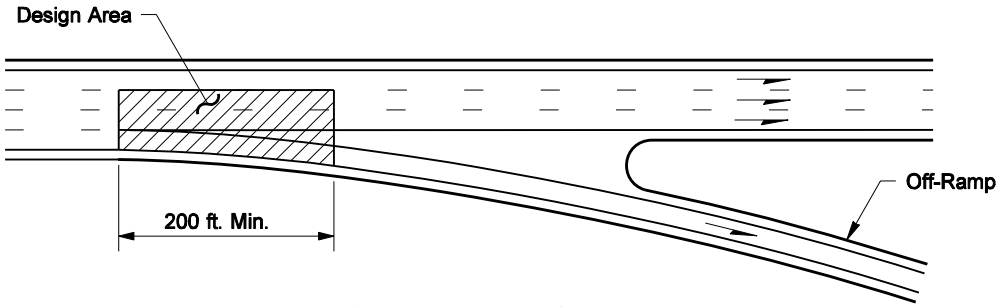
(c) **Standard Luminaire.** The cobra head style, high-pressure sodium vapor luminaire with Type III, medium cut-off light distribution is the normal light source used for state highway lighting. A Type III distribution projects an oval pattern of light on the roadway, and a Type V distribution projects a circular pattern of light on the roadway. Post top-mounted luminaires and other decorative light fixtures with Type V patterns are more effective for area lighting in parking lots and other locations where more symmetrical light distribution patterns are used.

840.08 Documentation

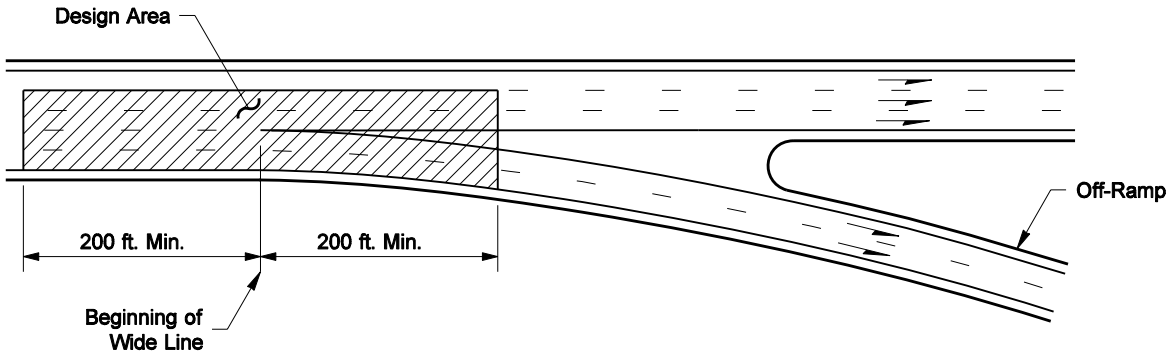
A list of the documents that are to be included in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



Required Illumination for a Typical Diamond Interchange
(Shown for Single-Lane Ramp Connection and a Two-Lane Crossroad Without Channelization)

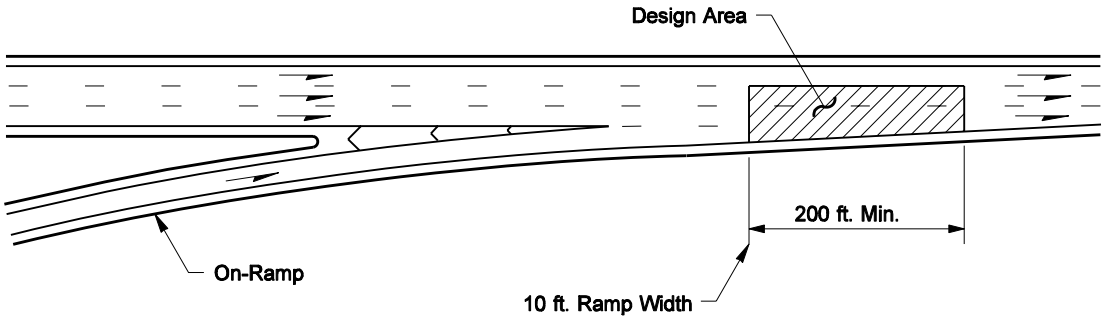


Single-Lane Off-Connection
(The Design Area May Be Shifted up to 100 Feet From the Beginning of the Wide Line)

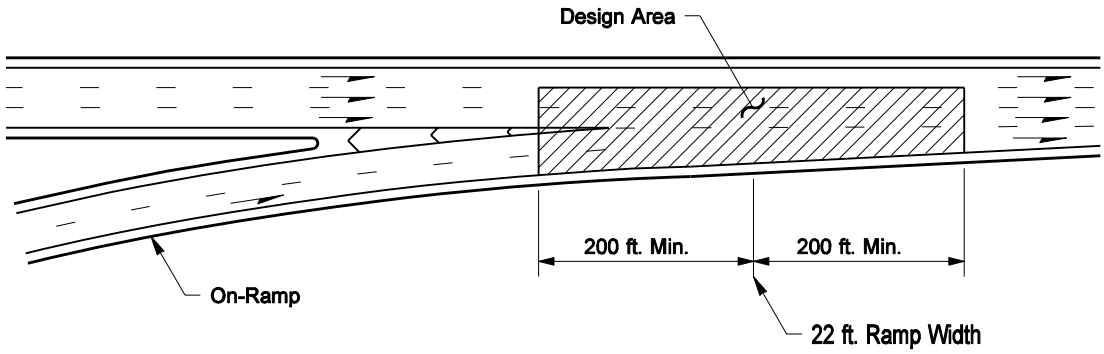


Two-Lane Off-Connection
(The Design Area Can Be Shifted up to 100 Feet From the Beginning of the Wide Line)

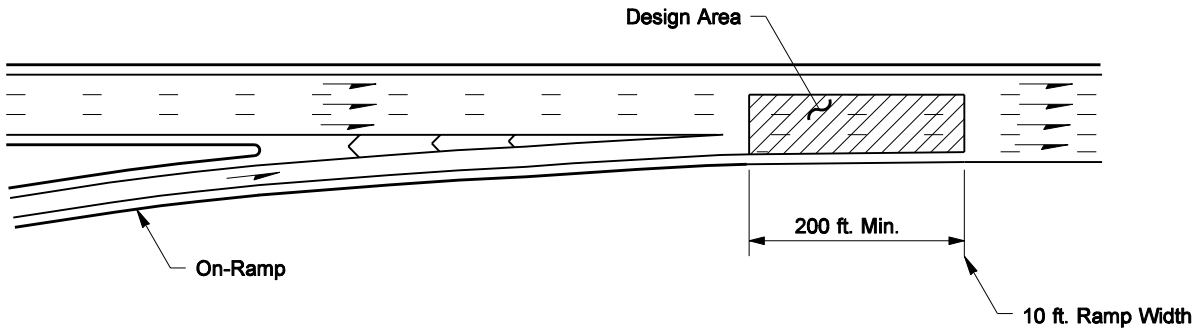
Freeway Lighting Applications
Figure 840-1a



Single-Lane On-Connection
(The Design Area May Be Shifted up to 100 Feet From the 10-Foot-Wide Ramp Point)



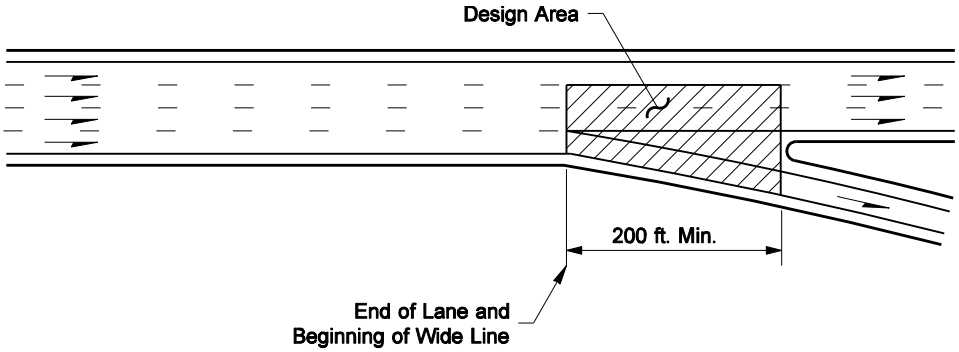
Two-Lane On-Connection
(The Design Area May Be Shifted up to 100 Feet From the 22-Foot-Wide Ramp Point)



Auxiliary Lane at On-Connection
(The Design Area May Be Shifted up to 100 Feet From the 10-Foot-Wide Ramp Point)

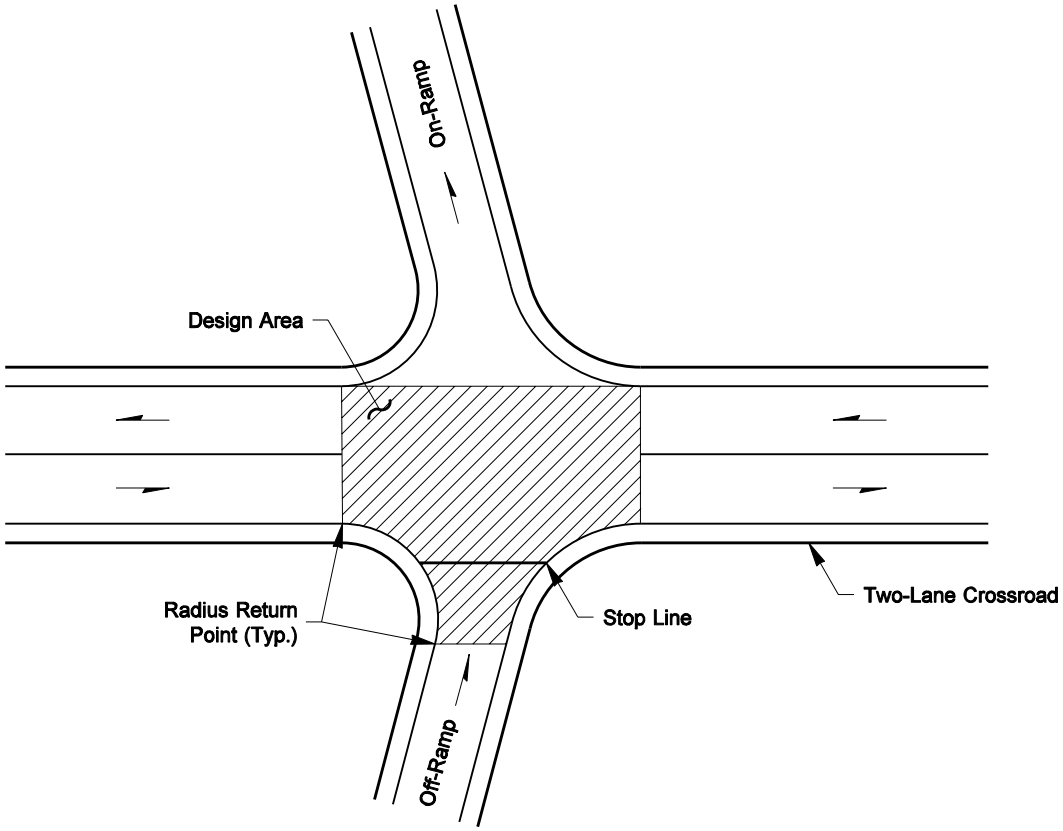
Freeway Lighting Applications

Figure 840-1b

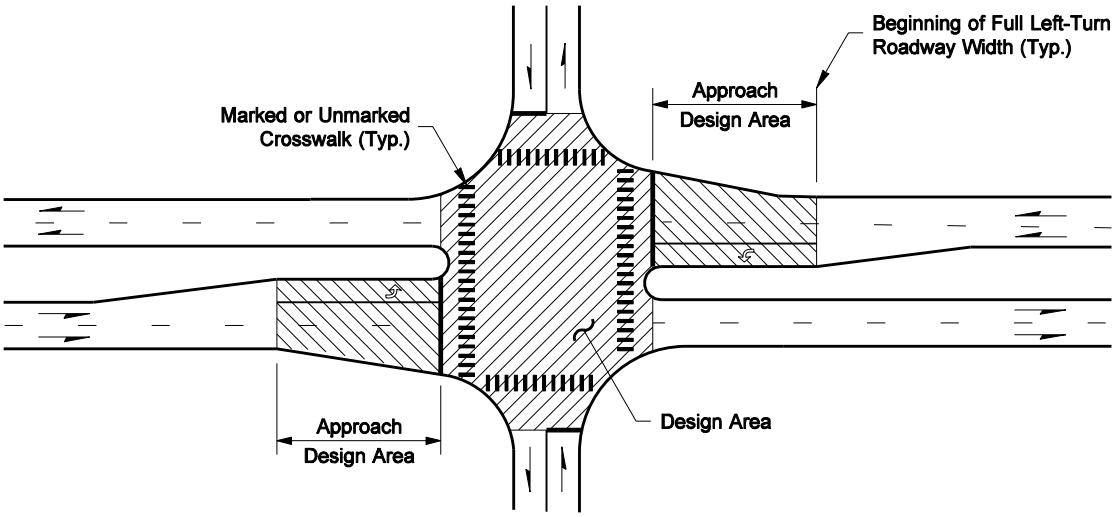


Exit-Only Lane
The Design Area May Be Shifted up to 100 Feet From the End of Lane and the Beginning of Wide Line

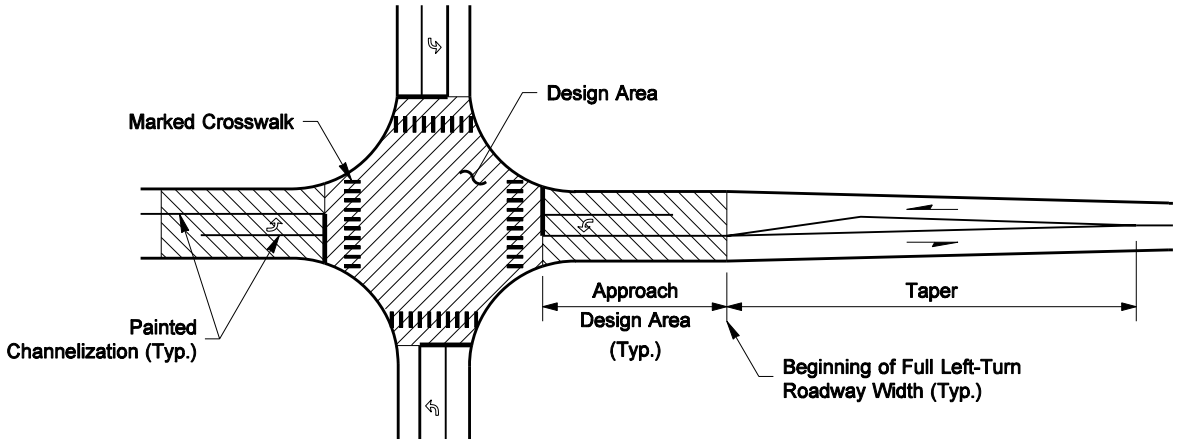
Freeway Lighting Applications
Figure 840-1c



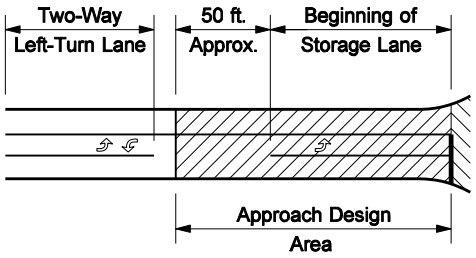
Freeway Ramp Terminals
Figure 840-2



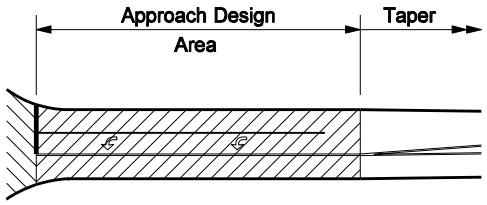
Intersection With Left-Turn Channelization
Figure 840-3a



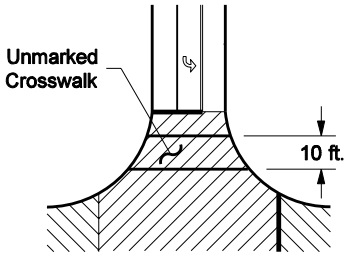
Intersection With Left-Turn Lane Channelization



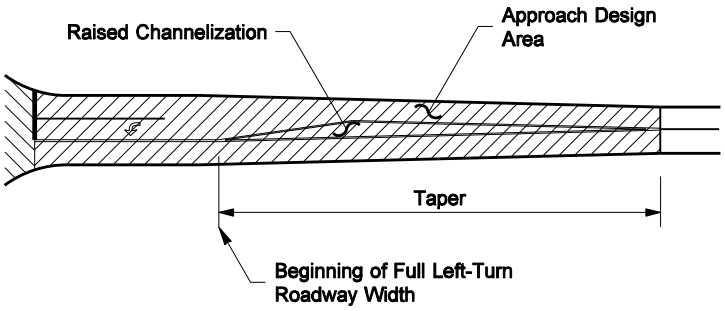
Alternate for Transitions to Two-Way Left-Turn Lanes



Alternate for Long Storage Lanes

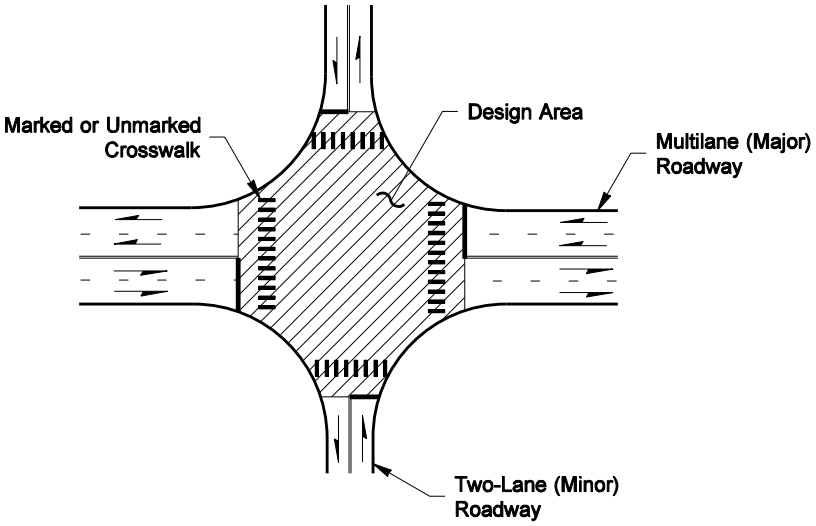


Unmarked Crosswalk Detail

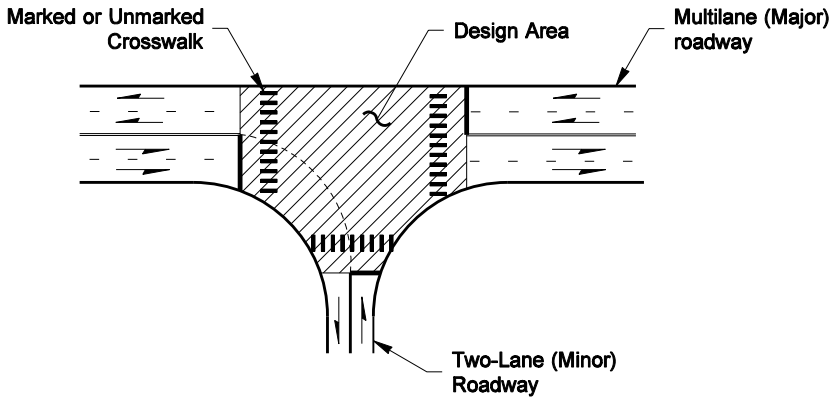


Alternate for Raised Channelization

Intersection With Left-Turn Lane Channelization
Figure 840-3b

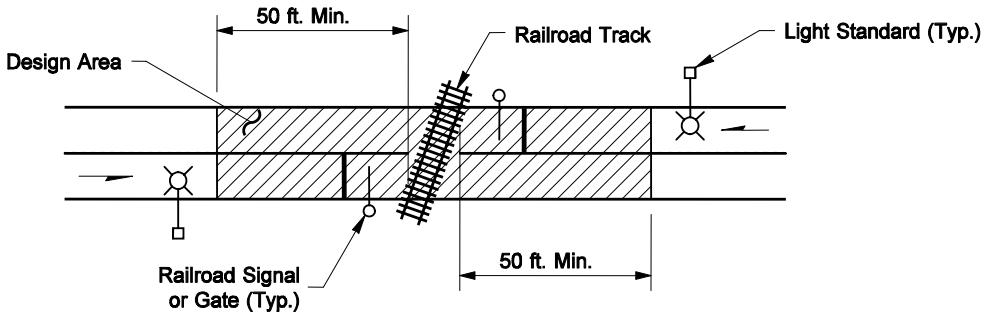


Four-Way Intersection
(Without Left-Turn Channelization)

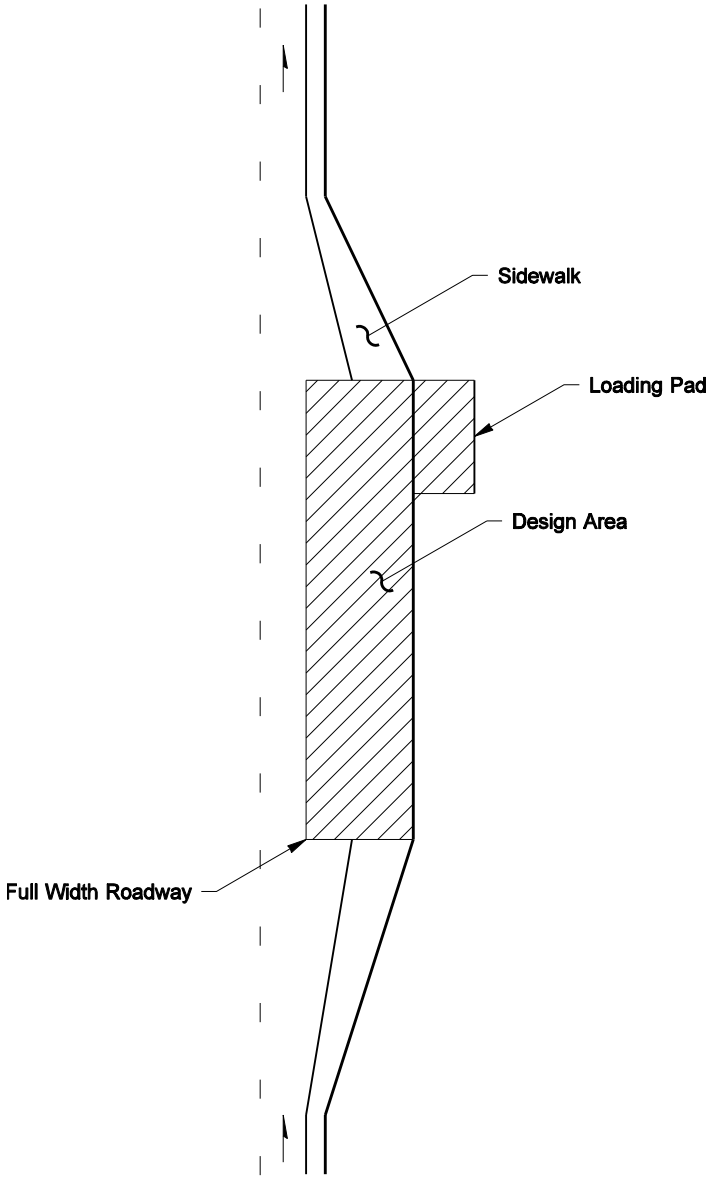


Major Tee Intersection
(Without Left-Turn Channelization)

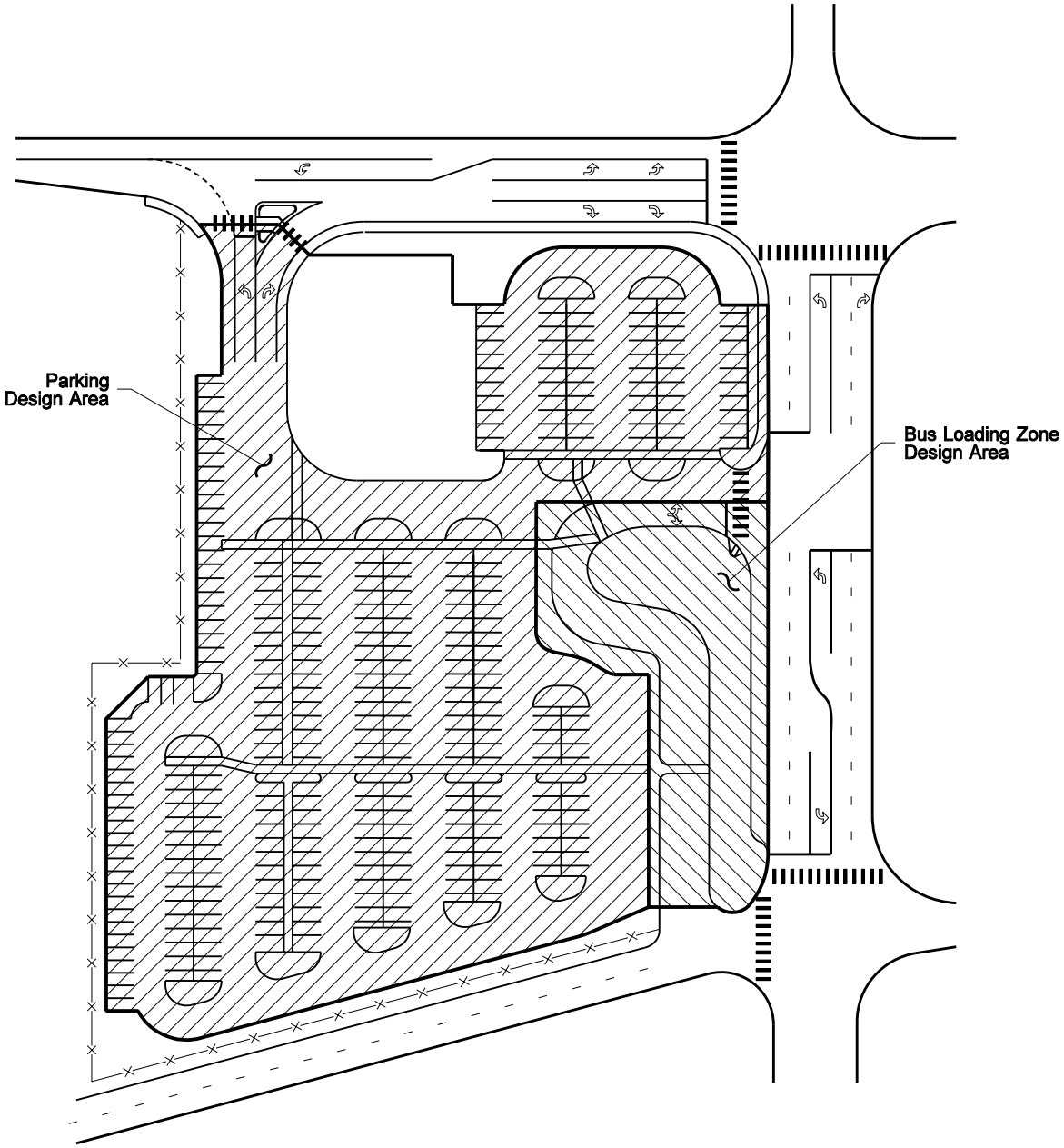
Intersection With Traffic Signals
Figure 840-4



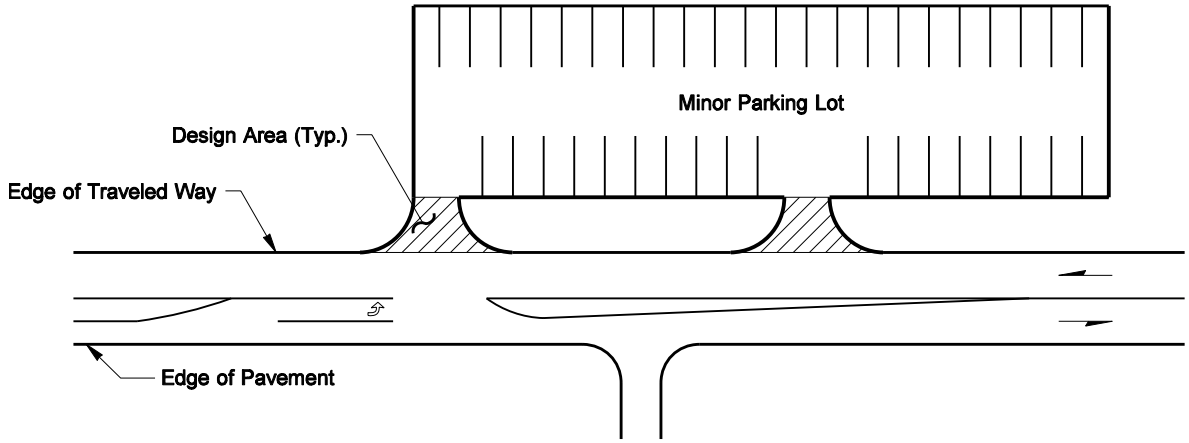
Railroad Crossing With Gates or Signals
Figure 840-5



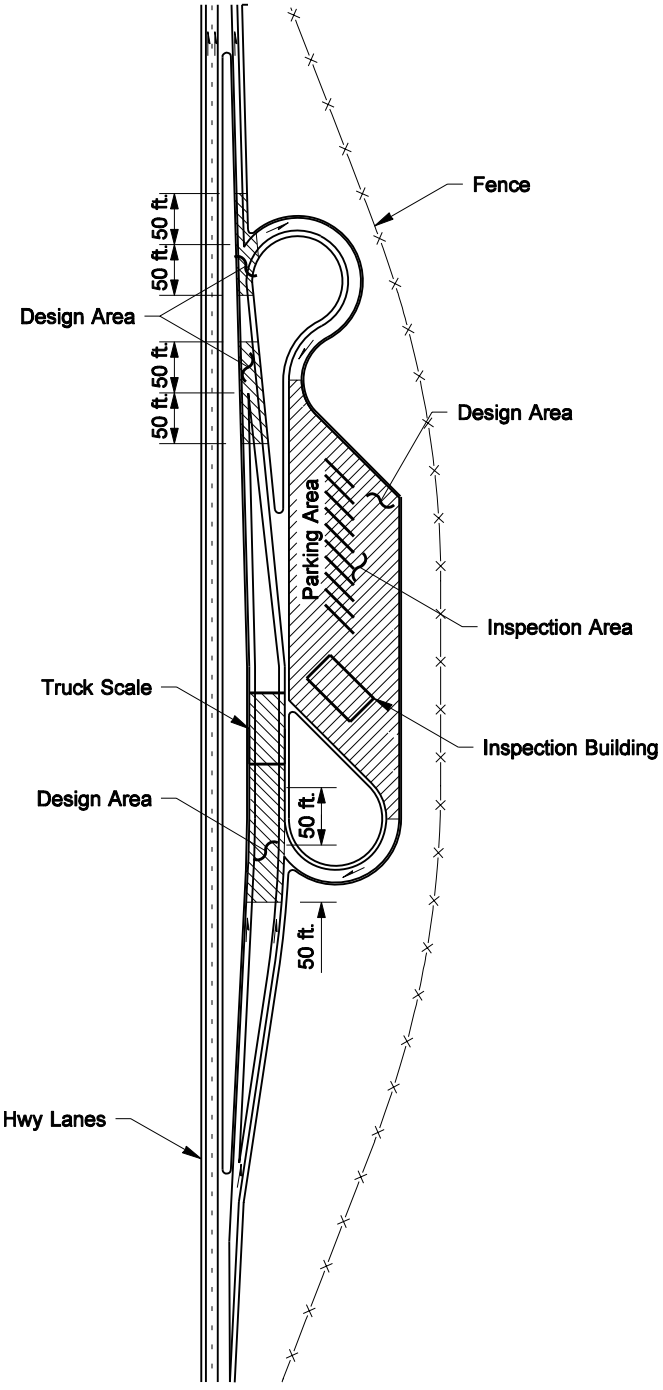
Transit Flyer Stop
Figure 840-6



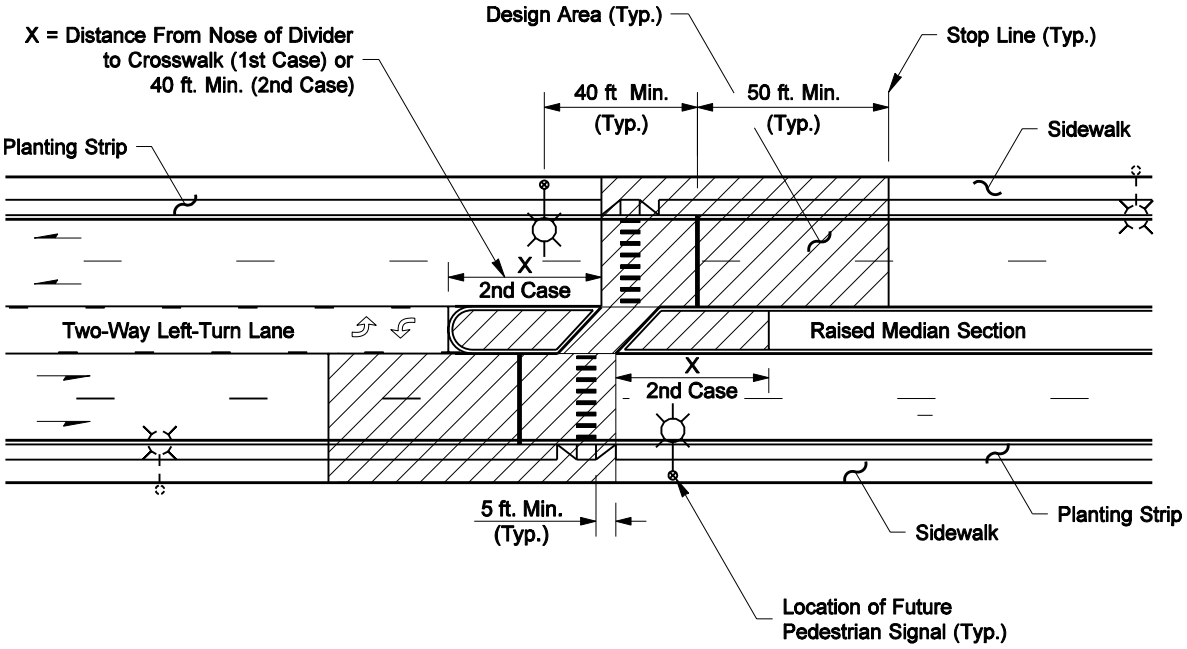
Major Parking Lot
Figure 840-7



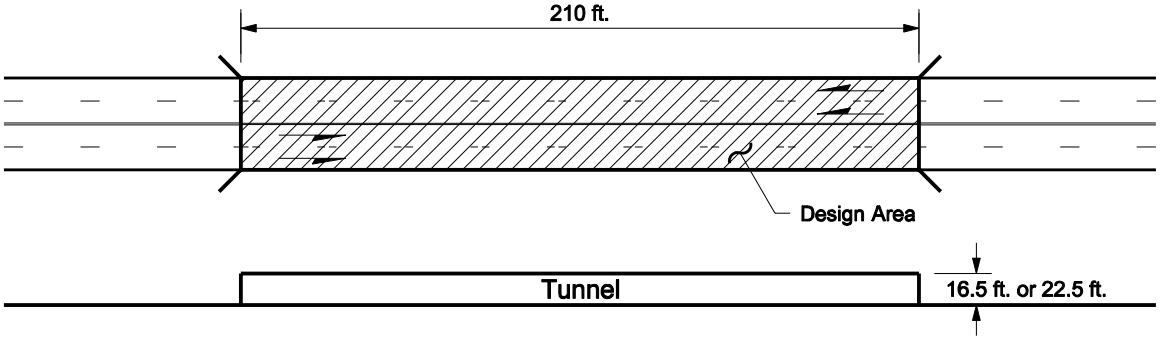
Minor Parking Lot
Figure 840-8



Truck Weigh Site
Figure 840-9



Midblock Crossing
Figure 840-10



If Tunnel Length Exceeds Stopping Sight Distance Then, It Is Classified As a Long Tunnel:

Example #1
- The stopping sight distance for a 30 mph roadway is 196.7'
- The tunnel length is 210'

196.7' < 210' - This is a long tunnel.

Example #2
- The stopping sight distance for a 40 mph roadway is 300.6'
- The tunnel length is 210'

300.6' > 210' - This is a short tunnel.

Determining Whether a Short Tunnel Needs Illumination:

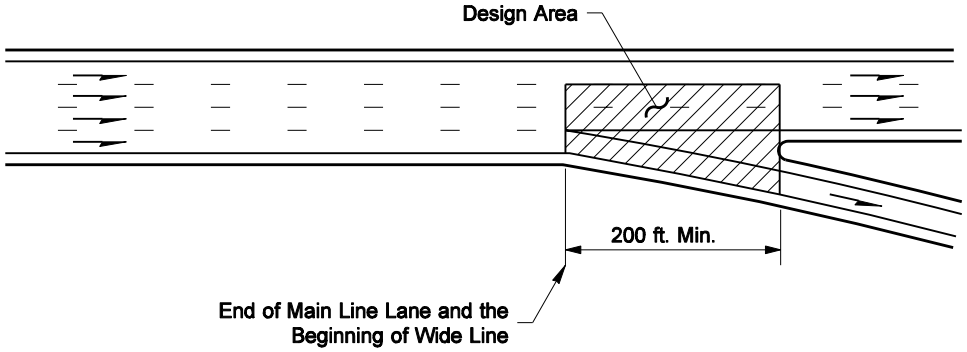
Example #1
- Vertical clearance is 16.5'
- Tunnel length is 210'

If horizontal-to-vertical ratio is 10:1 or greater, then illuminate.
210' divided by 16.5' = 12.7:1 - This ratio exceeds the short tunnel horizontal-to-vertical ratio of 10:1, so this tunnel needs illumination-OR-How long can the tunnel be at a given height before it needs to be illuminated?
Tunnel height x maximum ratio factor of short tunnel (10:1 or less).
16.5' x 10 = 165'
165' < 210' - This tunnel needs illumination.

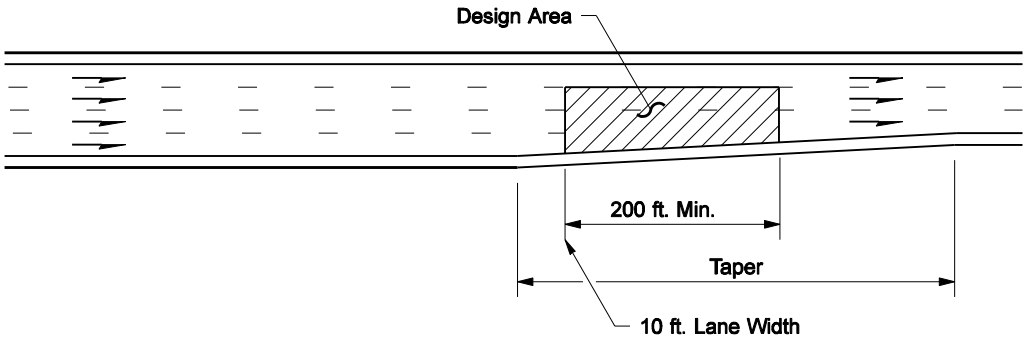
Example #2
- Vertical clearance is 22.5'
- Tunnel length is 210'

If horizontal-to-vertical ratio is 10:1 or greater, then illuminate.
210' divided by 22.5' = 9.3:1 - This ratio is less than the short tunnel horizontal-to-vertical ratio of 10:1, so this tunnel does not need illumination-OR-How long can the tunnel be at a given height before it needs to be illuminated?
Tunnel height x maximum ratio factor of short tunnel (10:1 or less).
22.5' x 10 = 225'
225' > 210' - This tunnel does not need illumination.

Tunnels
Figure 840-11

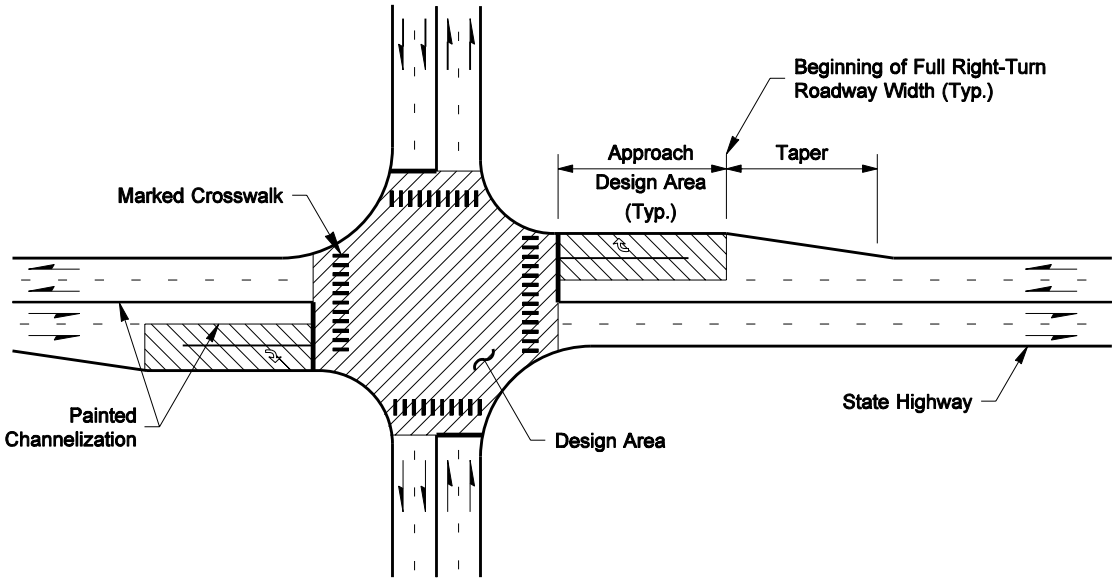


Main Line Lane Reduction
(The Design Area Can Be Shifted up to 100 Feet From the End of Lane and the Beginning of Wide Line)

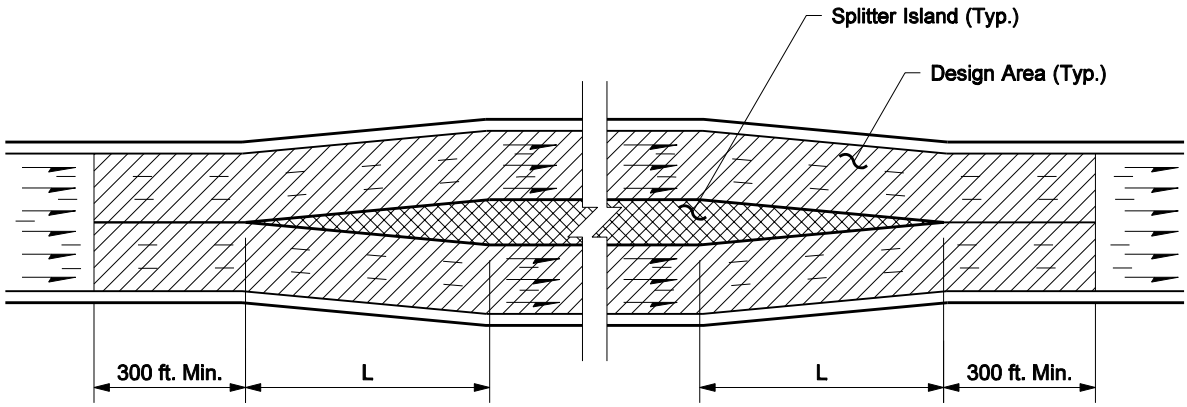


Lane Reduction

Lane Reductions
Figure 840-12



Intersection With Right-Turn Lane Channelization
Figure 840-13

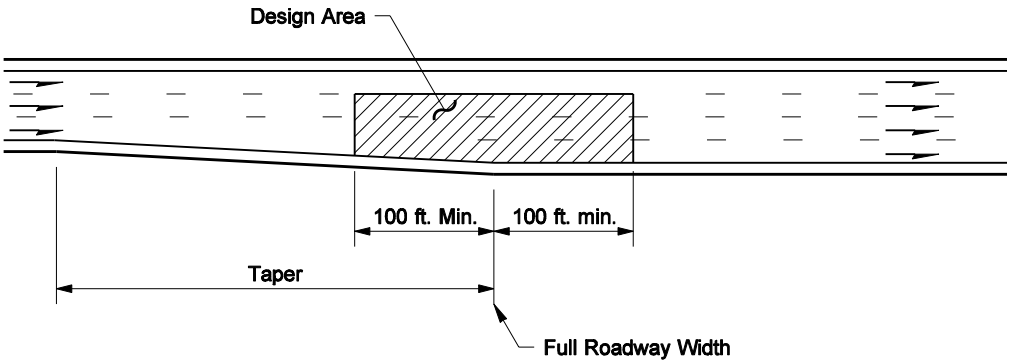


For speeds 45 mph or more: L = WS
For speeds less than 45 mph: L = WS/60

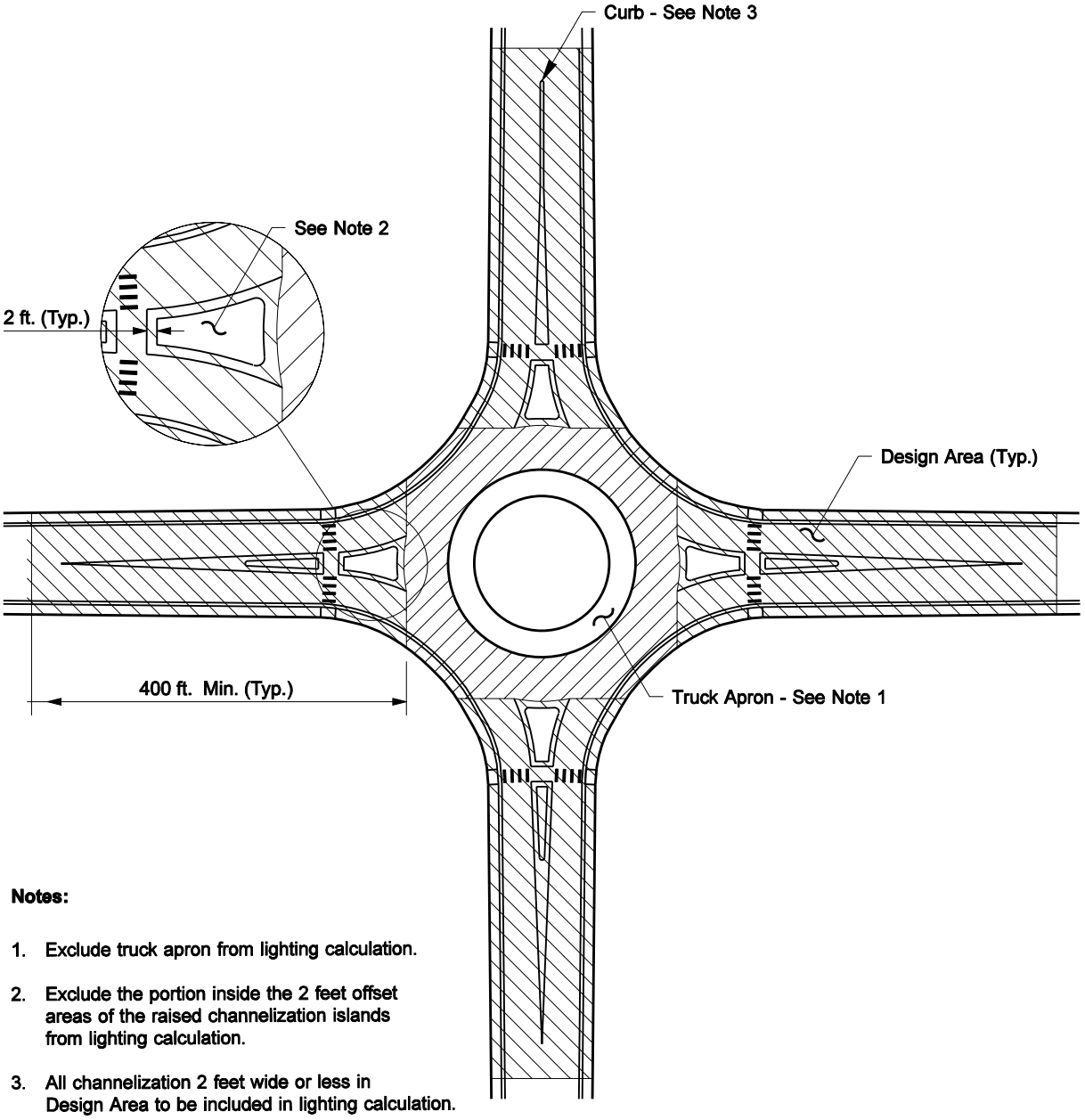
L = Taper length in feet
W = Width of offset in feet
S = Posted speed

For temporary Work Zone Plan applications a site-specific Traffic Control Plan is required. Refer to Chapters 710 and 720 for traffic barrier and attenuator information, Chapter 810 for Work Zone information, and Chapter 820 for signing information.

Traffic Split Around an Obstruction – Same Direction
Figure 840-14



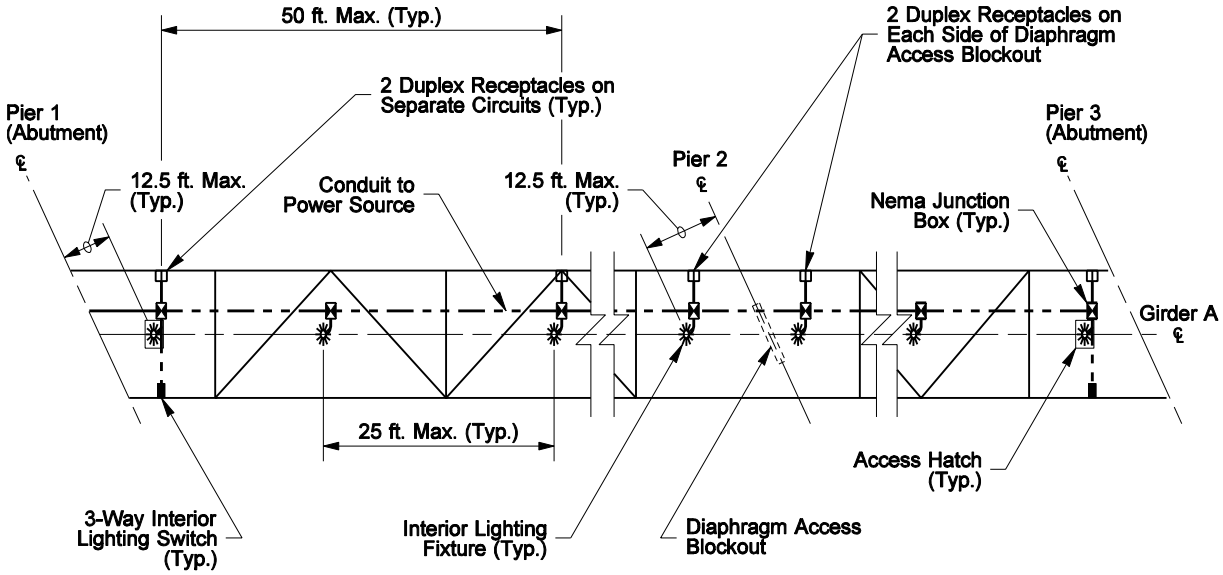
Add Lane
Figure 840-15



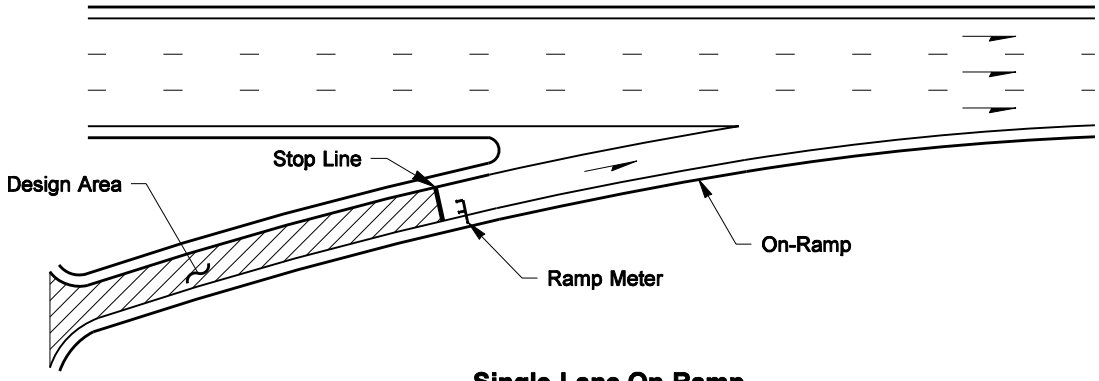
Notes:

1. Exclude truck apron from lighting calculation.
2. Exclude the portion inside the 2 feet offset areas of the raised channelization islands from lighting calculation.
3. All channelization 2 feet wide or less in Design Area to be included in lighting calculation.

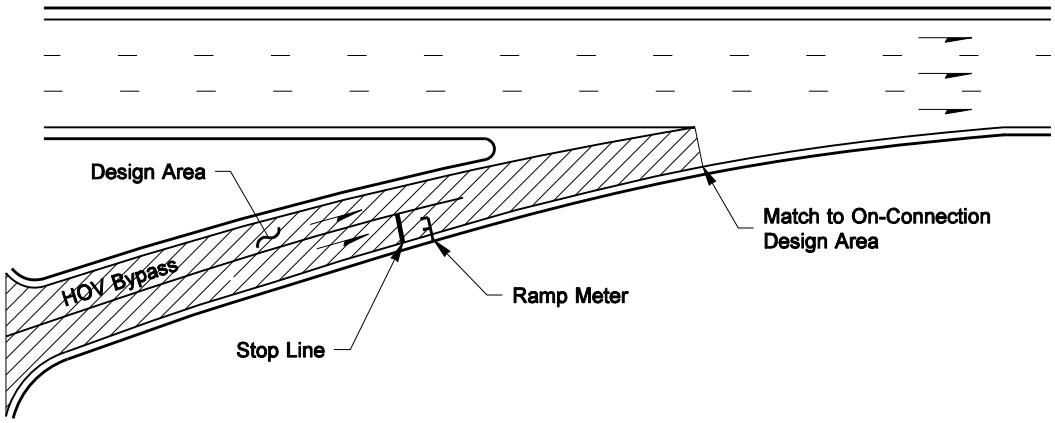
Roundabout
Figure 840-16



Bridge Inspection Lighting System
Figure 840-17

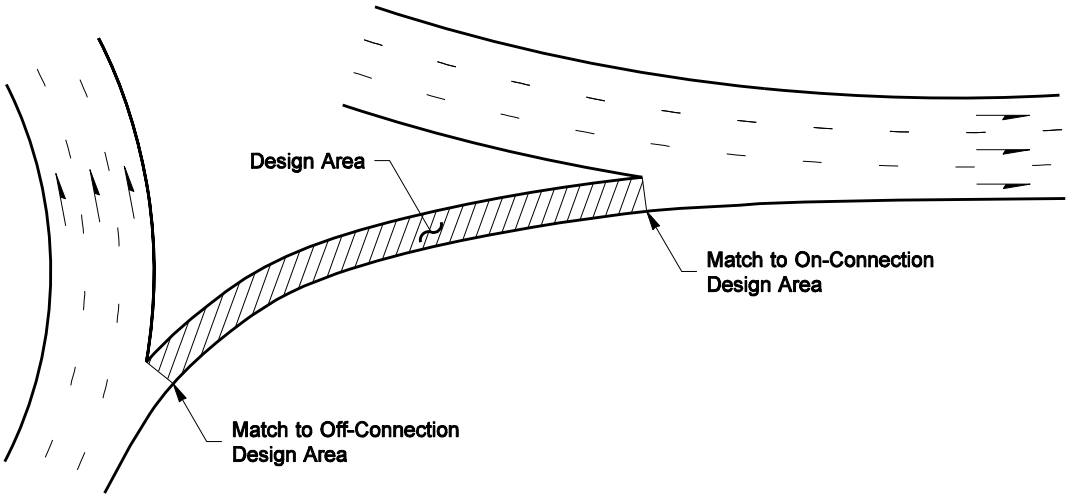


Single-Lane On-Ramp

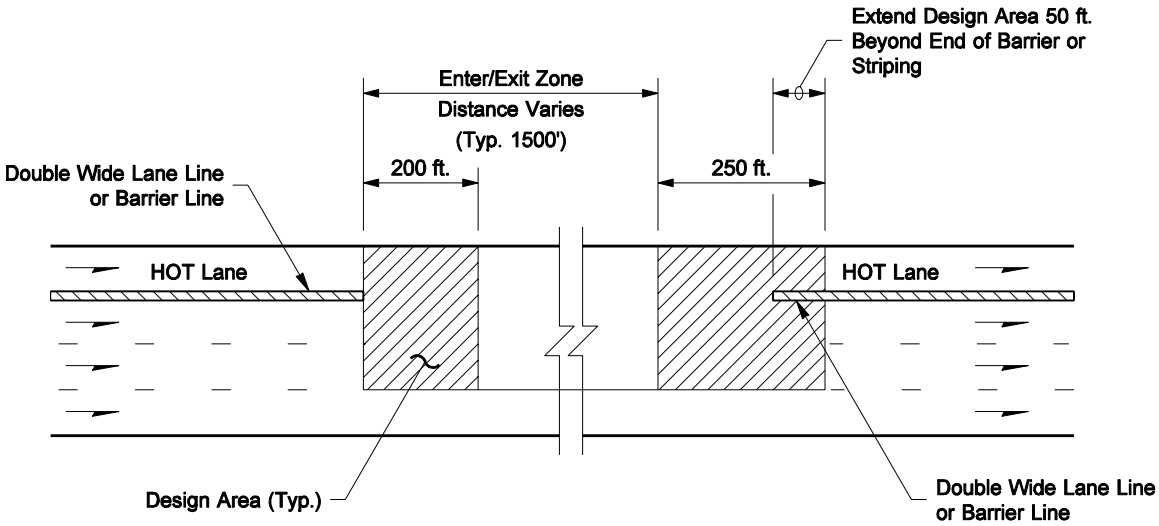


Two or More Lanes

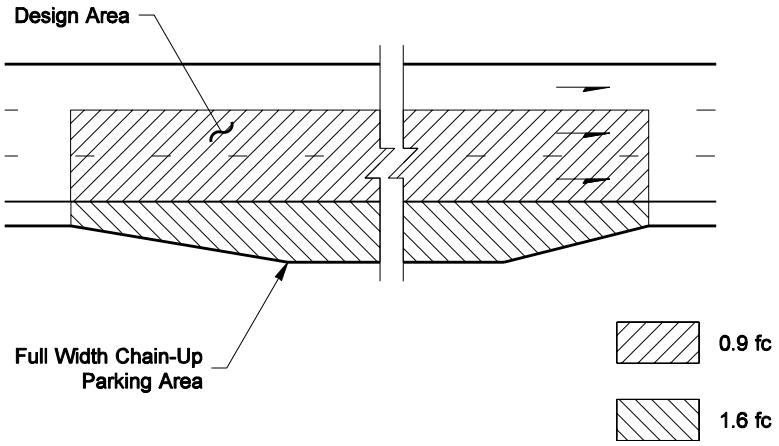
Ramp With Ramp Meter
Figure 840-18



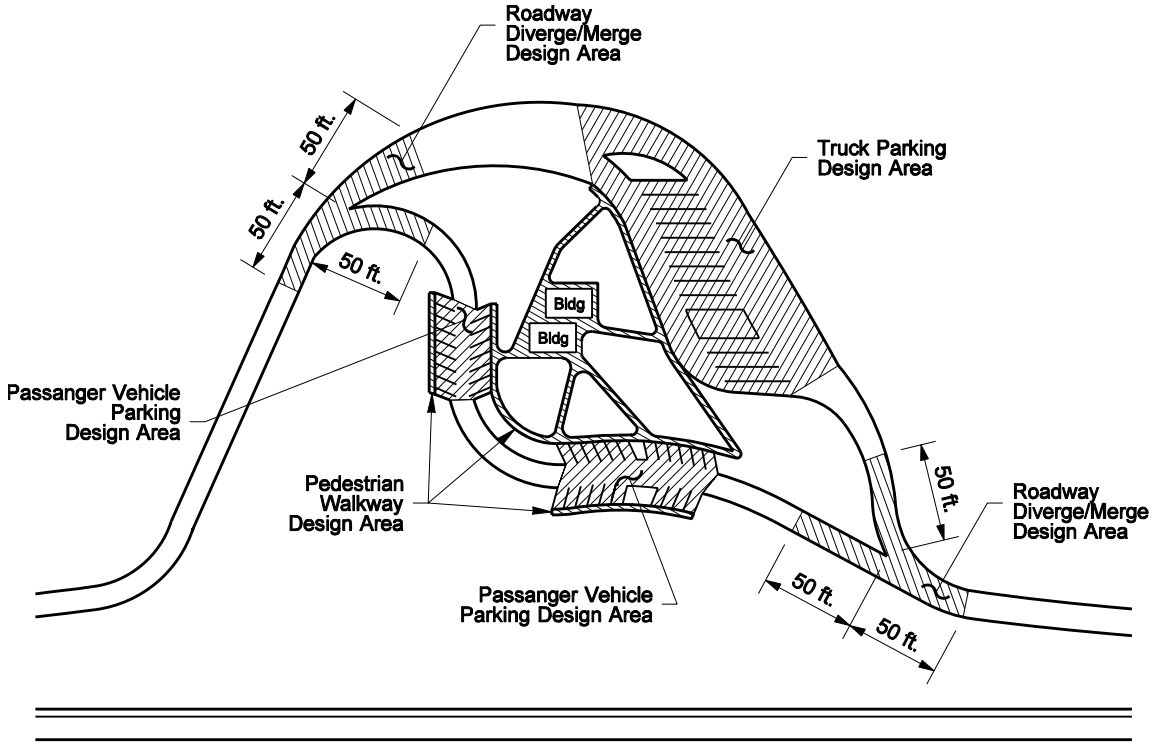
Freeway-to-Freeway Ramp Connection
Figure 840-19



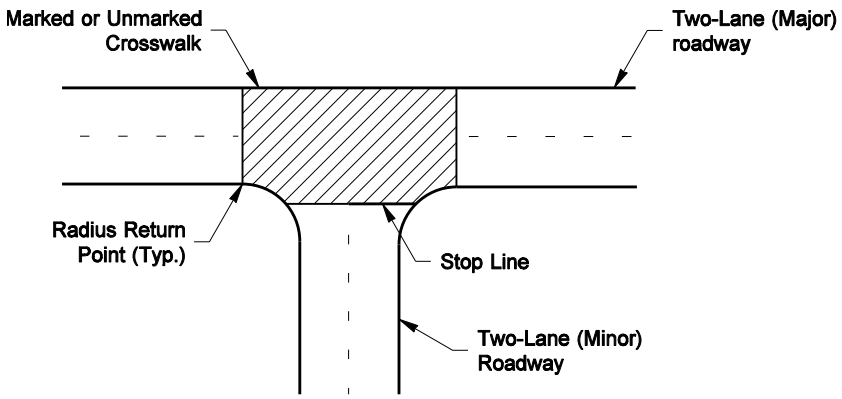
HOT (High Occupancy Toll) Lane Enter/Exit Zone
Figure 840-20



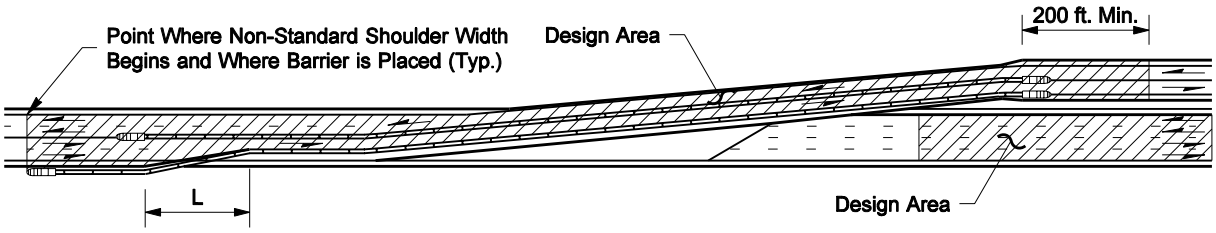
Chain-Up Parking Area
Figure 840-21



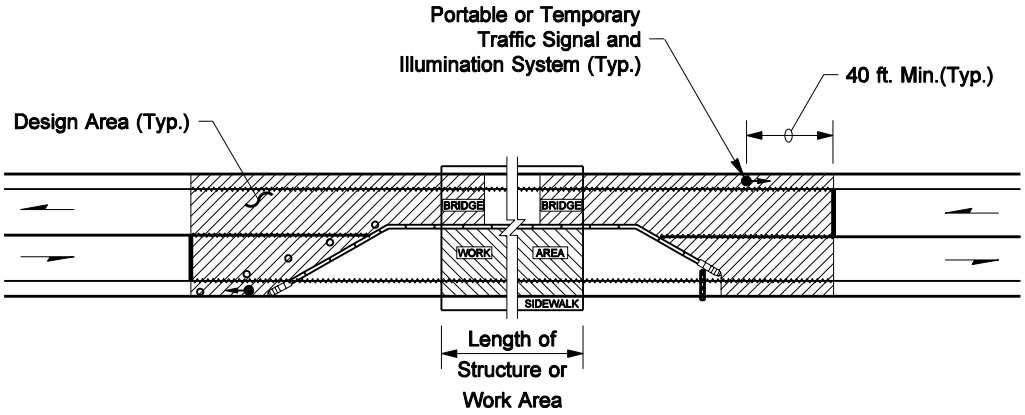
Rest Area
Figure 840-22



Intersection Without Channelization
Figure 840-23



Detour Traffic



Lane Closure With Barrier & Signals Without Flaggers or Spotters
(One Direction Closure Shown/Other Direction Closure Typical)

For temporary Work Zone Plan applications a site-specific Traffic Control Plan is required. Refer to Chapters 710 and 720 for traffic barrier and attenuator information, Chapter 810 for Work Zone information, and Chapter 820 for signing information. Refer to MUTCD Typical Application 12 for additional details.

Construction Work Zone and Detour
Figure 840-24

Light Level and Uniformity Ratio Chart					
Highway Design Class	**Minimum Average Maintained Horizontal Light Level(2)**			**Maximum Uniformity Ratio(6)**	**Maximum Veiling Luminance(7)**
	Pedestrian/Area Classification				
	High (footcandles)	Medium (footcandles)	Low (footcandles)		
Highways With Full Access Control(1)					
Main Line	0.6	0.6	0.6	4:1	0.3:1
Ramps	0.6	0.6	0.6	4:1	0.3:1
Crossroads	0.6	0.6	0.6	3:1	0.3:1
Ramp Intersections	0.9	0.9	0.9	3:1	0.3:1
Principal Arterials(3)					
Main Line	1.6	1.2	0.6	3:1	0.3:1
Intersections	1.6	1.2	0.9	3:1	0.3:1
Minor Arterials					
Main Line	1.2	0.9	0.6	4:1	0.3:1
Intersections	1.2	0.9	0.9	4:1	0.3:1
Collectors					
Main Line	1.1	0.8	0.6	4:1	0.3:1
Intersections	1.1	1.0	0.9	4:1	0.3:1
Construction Lanes and Detours	1.0	1.0	1.0	3:1	0.3:1
Major Parking Lots/ Rest Areas(5)	0.8	0.8	0.8	3:1	0.3:1
Vehicle Inspection Areas	2.0	2.0	2.0	3:1	0.3:1
Walkways & Bicycle Trails	0.8	0.8	0.8	3:1	0.3:1
Weigh Scales	0.8	0.8	0.8	3:1	0.3:1
Transit Stops(4)	2.0	2.0	2.0	NA(8)	0.3:1
Midblock Ped X-ing	2.0	2.0	2.0	3:1	0.3:1

Notes:

(1) The minimum light level is 0.2 footcandle (fc) for any application with a minimum average maintained horizontal light level of 0.6 fc. The minimum light levels for all other applications are controlled by the uniformity ratio.

(2) Light level and uniformity ratio apply only when installation of more than one light standard is justified.

(3) Light levels shown also apply to modified and partial limited access control.

(4) For single light standard installations, provide the light level at the location where the bus stops for riders. (See 840.06(6).)

(5) Includes illumination at ramp on and off connections.

(6) Minimum Average Maintained Light Level / Minimum Light Level = Maximum Uniformity Ratio.

(7) Maximum Veiling Luminance / Average Luminance = Maximum Veiling Luminance Ratio.

(8) The Maximum Uniformity Ratio is 3:1 when more than one light standard is justified.

Light Levels and Uniformity Ratios

Figure 840-25